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THE PROBLEM OF NONMETALLIC RAW MATERIALS (FLUXES) IN THE SOVIET METALLURGICAL INDUSTRY

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Among the raw material resources of Soviet ferrous metallurgy, fluxes occupy the fourth place in the order of their importance and their rate of consumption, following coke, ore, and scrap metal.

Fluxing agents are used to produce easily fusible slag in metallurgical processes and to dephosphorize and desulfurize. Desulfurization requires the production of basic slag, consisting of limestone, dolomite, or lime (calcined limestone). Dephosphorization also requires the use of limestone or other fluxes containing calcium oxide.

Bessemer steel production, which does not require limestone as a fluxing agent, takes place only in three Bessemer shops in the southern USSR, i.e., in the Metallurgical Plant imeni Petrovskiy in Dnepropetrovsk, the Metallurgical Plant imeni Dzerzhinskiy in Dneprodzerzhinsk, and the Makeyevka Metallurgical Plant.

Just as in the United States, in the USSR over 85 percent of all steel smelting is done by the open-hearth process in furnaces with a basic bottom (dolomite or magnesite).

In addition to open-hearth steel smelting, limestone is also used to some extent in blast-furnace operations. Depending on the silica content of iron ore in various regions of the USSR and the differences in coke content of coal obtained from various coal basins, the consumption of limestone per ton of pig iron varies between 0.2 and 0.7 ton or more, as seen in the following table.

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Table 1. Flux Consumption by Blast Furnaces in Different Regions (per ton of pig iron)

Region	Metallic Charge	Coke	Limestone
Southern USSR	2.0	1.0	0.6
Central European USSR	2.4	1.2	0.7
Urals (charcoal-fired furnaces)	2.0	--	0.2
Magnitka and Kuznetsk	2.0	0.9	0.35

Table 1 gives the average indexes for the last prewar years. During postwar years, because of poorer quality of coke (increased ash and sulfur content), consumption of limestone, both in the east and in the south, increased to 10 or 20 percent. The Magnitogorsk and Kuznetsk plants also increased their limestone consumption because of the higher sulfur content in Magnitogorsk ore.

The following table gives data for limestone consumption in blast furnaces of individual plants.

Table 2. Limestone Consumption in Pig-Iron Smelting (per ton of pig iron)

Plant	Open-Hearth Iron	Foundry Pig Iron	Bessemer Pig Iron
Makeyevka	0.58 - 0.60	--	--
Plant imeni Dzerzhinskiy	0.51 - 0.54	0.347 - 0.47	--
DZMO (Dnepropetrovsk)	0.52 - 0.55	--	--
Krivoy Rog	0.41	--	0.56
Kuznetsk	0.29 - 0.40 (Min 0.177, max 0.426)		
Kerch'	--	--	0.778 (Thomas pig iron)
Chelyabinsk	0.58	--	--
Khalilovo	1.10	--	--

In southern plants, limestone consumption in the basic open-hearth process amounts to 12 percent of the weight of finished steel. The relation of 0.12 ton of limestone to one ton of steel may be taken as the average figure for steel production in the entire USSR.

For the production of commercial steel and with the use of pure furnace-charge materials, the consumption coefficients may be lowered to 0.10. For the production of high-quality steel, the coefficient rises to 0.12 or 0.14, and for the double open-hearth process, up to 0.15. In the Thomas process used at the Kerch' Plant, limestone consumption is from 16 to 22 percent. In electric smelting, flux consumption amounts to 16 percent. Considering the fairly large percentage of electric smelting done in acid furnaces, the average coefficient of 0.12 may also be accepted for electric metallurgy. In cupola furnaces, limestone consumption amounts to 0.04.

In addition to the use of limestone in metallurgical processes, it is also used in the production of slag cement. In this case, the average consumption is 36-37 percent of the weight of finished cement.

In the absence of direct data on the total consumption and output of limestone by Soviet metallurgy, the following computations are based on the quoted coefficients, using data for 1933, when the limestone output was 5 million tons and the pig-iron output 7.13 million tons (or 70 percent of limestone per ton of pig iron), as well as 1938 data, when the limestone output was 9.5 million tons and the pig-iron output 14.8 million tons (or 65 percent limestone per ton of pig iron). It may be assumed, therefore, that the limestone-consumption coefficient in prewar years equaled 0.65 - 0.70.

During the war, only the eastern metallurgical enterprises were in operation, and they used a lower percentage of limestone. However, at the same time, consumption of local iron was increased for the operation of the Kuznetsk Metallurgical Combine, and the use of Magnitogorsk ore, which has a higher sulfur content, was also increased. As a result, consumption of limestone during the war may be considered on the same level as prewar consumption, especially since the ash content of Kuznetsk coke had increased and more Karaganda and Kizel coal was used for coking purposes, both of which coal types have a higher ash content and consequently require more fluxes. This was confirmed by calculations of Soviet metallurgists, who determined the increase in limestone consumption as 10.5 - 11 percent for each percent of increase in ash content of coke.

After restoration of the southern Soviet metallurgy, consumption of limestone per ton of steel increased due to the fact that the postwar quality of Donbass coke was far below prewar indexes, as shown by the following figures. During the first 6 months of 1948, the coal delivered to coal washers of coal-chemical plants contained an average of 18.7 percent ash as against 13.96 percent in 1940.

To determine the output and consumption of limestone during the war, the ratio of 0.325 to one ton of ore may be accepted as a control figure.

Table 3 gives data on limestone consumption in ferrous metallurgy during the Second and Third Five-Year Plans; the figures for the war years and the postwar period are given in Table 4.

Table 3. Pig-Iron Smelting and Limestone Consumption in the USSR
(1930 - 1942)

Year	Pig-Iron Output (million tons)	Limestone Consumption (million tons)
1930	4.964	3.5
1932	6.177	4.3
1933	7.131	5.0
1934	10.495	7.3
1935	12.613	8.2

Year	Pig-Iron Output (million tons)	Limestone Consumption (million tons)
1936	14.312	9.3
1937	14.500	9.4
1938	14.800	9.5
1939	--	--
1940	15.500	11.6 (11.95, according to plan)
1942	--	14.8 (plan figure)

The above-listed figures may, to some extent, serve also as indexes for the output of limestone, since limestone production for stockpiling purposes did not exceed limestone consumption by more than 5 or 6 percent and therefore can have no noticeable effect on the total figure.

Table 4. Limestone Consumption in Soviet Ferrous Metallurgy (1942 to 1947)

Year	1942	1943	1944	1945	1946	1947
Limestone consumption in million tons	4.2	4.5	4.9	6.6	7.6	8.7

The figures for the war years and the postwar period require some explanation. In prewar years, the calculations were based on official statistical data for pig-iron smelting. In the postwar period, because of the secrecy concerning volume of production, it was necessary to use comparative data for the production increase and the output of pig iron for a certain period as compared with the preceding year. Actual figures may deviate to the extent of 10-12 percent from the quoted figures; however, for the purpose of thes calculation, these figures are sufficiently exact. It may be added that they indicate the upper limit, i.e., the maximum of possible consumption.

According to the 1950 plan, 19.8 million tons of pig iron and 25.4 million tons of steel were to be smelted; one may assume, therefore, that the required output of limestone would be 19.8 x 0.6 plus 25.4 x 0.12, i.e., approximately 15 million tons.

To achieve a similar output in 1947 with a limestone output of approximately 9 million tons, the Main Administration of Nonore Minerals would have to take definite steps to increase prospecting work, expand mine development, and improve mechanization of quarries. However, judging by the prewar condition of mine development in nonore-mining industries and by its recent condition, it is doubtful whether the metallurgical industry can reach its production goals unless special measures are enforced.

It is interesting to note that, according to the Third Five-Year Plan, the 1942 output of metallurgical limestone was to be 14.8 million tons. As we know, the smelting plan for that year provided for 22.4 million tons of pig iron and 25 million tons of steel, i.e., close to the requirements for 1950. This coincides with our calculations and proves their correctness. If the 1942 plan provided for a larger pig-iron output and a lower limestone consumption than the 1950 plan, this was due to the fact that in preparing the Third Five-Year Plan, a lower coke consumption and a lower ash content of coke was taken into consideration.

Table 5 gives data on limestone consumption for various metallurgical regions for the years 1938 - 1942. The figures are taken from Soviet statistics for the year 1940. The 1938 figures are actual consumption indexes, while the figures for succeeding years are planned indexes.

Table 5. Consumption of Metallurgical Limestone in Various Regions of USSR (million tons)

Year	South	Center	Urals	West Siberia	Far East	Total
1938	6.9	0.9	1.2	0.5	--	9.5
1940	8.7	1.0	1.6	0.65	--	11.95
1942	9.5	1.4	2.9	0.8	0.2	14.8

Compared with the extent of iron-ore prospecting, deposits of flux materials have been much less investigated. For example, out of more than 100 deposits in the Urals, only ten or twelve points have been prospected, and reserves have been confirmed only in five of these deposits.

The geographic distribution of quarries and deposits does not correspond to the location of metallurgical plants. In a number of regions, local raw materials are used insufficiently or not used at all, due to the fact that they are not sufficiently investigated and are of poorer quality.

The number of operating quarries is not large. The entire Dnepr-area group of metallurgical plants uses limestone from the distant Yelenovka and Karakuba quarries, located in the Donbass. Fifteen plants in the northern and central Urals, as well as metallurgical plants of the Kama region, receive their supply of limestone from one source, i.e., the Nizhniy Tagil Quarry. For this reason, a group of metallurgical plants in the Upper Kama region spent eight to nine times more for hauling and reloading operations in 1939 than the cost of fluxes, according to the regular purchase price. The Dnepr area has always felt irregularities in the supply of limestone because of transport difficulties during the winter snowdrifts.

While there is a lack of mechanization in the ore-mining industry, conditions are even worse in the flux industry. Mechanization has been introduced only partially, and even then, only in the large quarries. Before the war, forced labor was used for all manual work processes; during the war and for some time thereafter, prisoners of war were used; and in recent years, repatriates from Germany and Austria have been employed in this type of labor.

It should be mentioned that the organizational and operational work in this field has also been lagging considerably as compared with other branches of industry. In most of the quarries, no facilities were available for crushing, sorting, and preliminary processing of limestone. There is no regular system for taking samples after cutting.

Most of the quarries do not have prospected reserves, and mine sectors are not developed for exploitation. Mining operations in many quarries are poorly handled, and safety rules are often ignored. As a rule, stripping operations lag behind mining operations. In some quarries, blasting is done before removal of the overburden, as a result of which the limestone is mixed with various impurities.

Briefly, the tasks confronting production of fluxes for ferrous metallurgy are as follows:

In the South, the Yelenovka and Karakuba quarries must be reconstructed and expanded. The utilization of local limestone in the Dnepr region should be increased, for which purpose local deposits must be prospected and assayed. The nonore-mining industry of the Urals should also increase the use of local limestone.

Deposits of operating quarries should be further investigated and assayed and their reserves estimated. Geological service should be organized in the large quarries. Mining sectors must be developed for exploitation, and regular samples of fluxes should be taken.

Quarrying operations must be conducted more efficiently, production costs must be lowered, and mining, loading, and stone crushing must be mechanized.

Concentration plants should be built wherever possible.

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